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Technical Information

403, 413, 423

BENCH VARIABLE

POWER SUPPLIES

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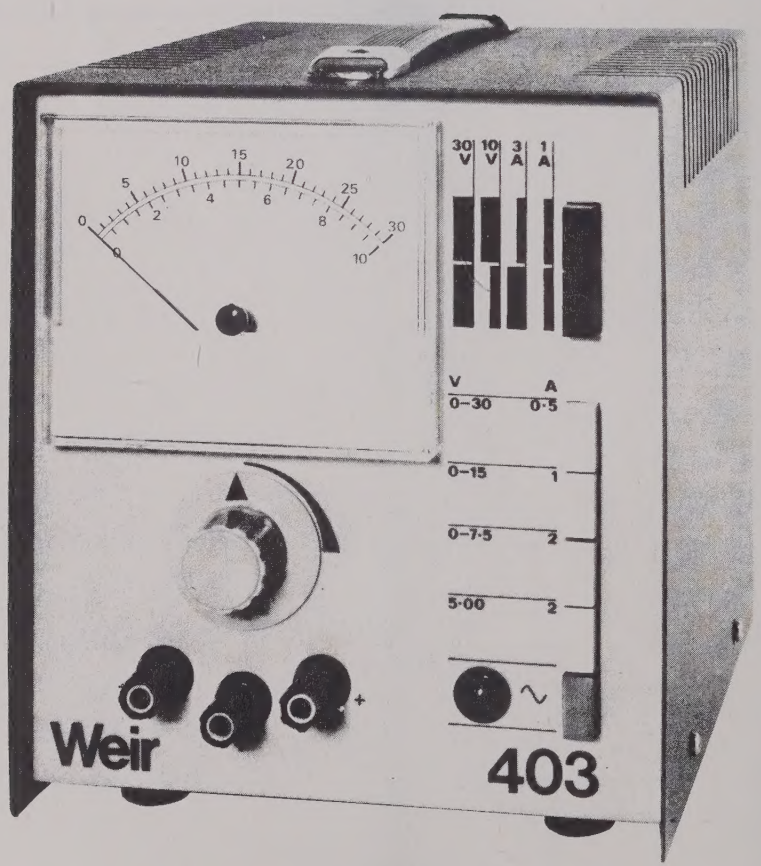

Front View Type 403

403 SERIES BENCH VARIABLE POWER SUPPLIES - Types 403/413/423

1.0 INTRODUCTION

The 403 Series of bench power supplies are 4-range units providing the following outputs:-

403	0-30V at 0·5A;	0-15V at 1·0A;	0-7·5V at 2·0A;	5V at 2·0A
413	0-30V at 1·0A;	0-15V at 2·0A;	0-7·5V at 4·0A;	5V at 4·0A
423	0-60V at 0·5A;	0-30V at 1·0A;	0-15V at 2·0A;	5V at 2·0A

In addition, a 'D' option on each unit provides a centre tap, the accuracy of which is specified down to a total supply voltage of 4V (i.e., ±2V supply). A further 'T' option gives a 10-turn voltage control with dial for increased resolution and resetability.

All units use the same basic case and internal construction with identical heatsinks and main printed circuit board, changes to component values and types determining the difference between the units. The 'D' option variants have an additional circuit board which controls the centre tap, together with a pair of extra power transistors on the heatsink.

2.0 OPERATING INSTRUCTIONS

The unit requires a 50 to 60Hz AC ONLY input power supply. The captive power lead to the instrument should be connected to a 3-pin power plug. The lead is colour coded:- brown = live, blue = neutral and green/yellow = earth.

INCORRECT CONNECTION OF THE POWER LEAD, OR CONNECTION TO A SUPPLY WITH NO EARTH, IS DANGEROUS.

Set the voltage selector on the rear of the unit to the correct input supply voltage, connect the a.c. supply and switch ON by depressing the red push-button.

With none of the grey 'range select' push-buttons depressed, the supply gives no output. Depress the push-button for the supply range desired, noting that the lowest grey button gives a 5V output regardless of the position of the voltage potentiometer. In order to avoid possible damage to loads caused by inadvertent range changing, the push-buttons are independently operated. To change ranges, release the already selected range by pushing the button a second time, then depress the button for the new range desired.

If more than one grey button is depressed at a time, the output supply will correspond to the lowest selected voltage and the output current limit to the lowest selected current. This facility can be of use if a current limit lower than the maximum is required on any of the lower voltage ranges.

The output voltage control potentiometer is not calibrated; however, the front panel markings (or the dial settings on 'T' versions) can be used for resetting to a previously set voltage. Note that, in order to ensure full voltage availability on all ranges, a small amount of voltage overrange is provided. Similarly, in order to ensure full current availability, the nominal current limit values are 10% higher than the values marked.

On 'D' versions, the centre tap voltage is guaranteed to be 49 to 51% of the output voltage ±100mV down to 4V total output. The current limit will operate if the current in either half of the supply exceeds the limit value. Both halves of the supply, however, will be reduced in voltage together as the current limit operates.

With both black push-buttons released, the meter reads output voltage with a full scale equal to the highest range. Depressing the top meter push-button changes the meter to current reading. Depressing the lower button increases the meter sensitivity by a factor of 3 on both voltage and current. There are, thus, a total of four meter ranges. On centre-tapped units ('D' option), the meter reads the total supply voltage on voltage ranges and whichever is the higher of the load currents on current ranges.

To obtain extra power, higher voltage or multi-rail configurations, units may be connected in series. Parallel operation is not recommended; unless the output voltages are set precisely equal, a step in output voltage will occur at half the total output current as one unit enters 'current limit'. The multi-range capability of these units largely obviates the need for parallel operation. For example, if 30V at 2A is required from two Mini 413 or 423 units, set both to 15V at 2A and connect them in series, rather than setting them to 30V at 1A and connecting them in parallel.

All the supplies in the range rely upon adequate cooling of the heatsink and internal components for correct operation. DO NOT obstruct the airflow by placing other equipment or papers on top of the units when they are operating.

3.0 TECHNICAL DESCRIPTION

This description should be read in conjunction with Fig. 2 (The Power Supply Circuit Diagram). The a.c. input is fused by FS1, double-pole switched by S7A and S7B and applied to the transformer primary via the voltage selector. This connects the primaries in series or parallel and adjusts the taps to suit the input voltage. The secondaries are connected in series or parallel by S3A, S4A, S5A and S6A to provide the correct unregulated voltage for the selected range.

With S6 or S5 depressed, secondary 3 is connected in parallel with the series combination of secondaries 1 and 2 to give the lowest voltage, highest current output to the rectifier. If either S3 or S4 is depressed at the same time, the combination of secondaries 1 and 2 is disconnected; as this action automatically lowers the current limit, secondary 3 can supply the load. With S4 depressed, secondaries 1 and 3 are connected in series for the middle output range; depressing S3 simultaneously with S4 has no effect as S4 has disconnected one end of the secondary 2. With S3 depressed, secondaries 1, 2 and 3 are connected in series to supply the highest voltage range.

The a.c. output from the transformer is rectified by MR2, MR3, MR4 and MR5 (BR1 on 413), with C2 acting as the reservoir capacitor. VT10 (and VT11 on 413 and 423) is the series regulator transistor with R29 providing current sensing. On 413 and 423, R29 and R30 also act to ensure current sharing between VT10 and VT11. The output is decoupled by C8 (C13 on centre-tapped units) with MR13 acting as protection against reverse voltage in the event of one supply being switched off when two supplies are being used in series.

Secondary 4 of the transformer is a low current secondary supplying power to the control and driver circuits. Its output is rectified by MR1 and filtered by C1. Note that the negative rail of the control supply is common to the positive rail of the output. R21, R22, VT8 and MR12 act as a constant current source supplying current to the main reference rail. This rail is stabilised by the amplifier VT6 and VT7, with MR11 acting as feedback round this amplifier. The regulated rail is, therefore, 5·6V plus the base emitter forward voltage of VT6 and appears at the emitter of VT7. R19 sets the standing current through MR11. The excess current from the collector of VT7 is used as the base drive for the driver transistor VT9.

R2 and RV2 provide a preset adjustable voltage for the voltage amplifier on the variable ranges. R5, R6 and R7 convert this into a reference current. Depressing S5 connects R5, R6 and R7 in series to provide the lowest reference current and, hence, the lowest output voltage range; as S5B has disconnected S4B and S3B, depressing these simultaneously does not affect the output voltage. Depressing S4 connects R5 and R6 in series to give the middle range; again, S4B disconnects S3B so that depressing S3B does not affect the output voltage. With S3 depressed, R5 provides the reference current. This switching arrangement ensures that the output is always the lowest of the selected voltages.

The reference current is balanced against the feedback current drawn by RV6 through MR7 and, as the base current of VT1 is negligible, these are equal. Note that, as the bases of VT1 and VT6 are both one forward-biased diode voltage drop above the positive output, their emitter base voltage drops cancel and MR11 determines the voltage across R5, R6 and R7. Similarly, the forward voltage drop of MR7 cancels the forward voltage drop of VT1 base, so that the voltage across RV6 is equal to the output voltage. Temperature variations in VT1, VT6 and MR7, therefore, cancel.

The action of the feedback loop is as follows: Should the output voltage increase, the extra current through RV6 causes VT1 to turn off slightly, reducing its collector current. Some of the current from R8, therefore, diverts through MR9 and into the emitter of the common base stage VT3. This current flows from the collector of VT3 into the base of VT4, causing its collector current to increase. As a result, emitter follower VT5 also draws more current from VT7, reducing the drive to VT9 and, hence, the output stages. This, therefore, causes a change in output to oppose the initial change and stabilises the output voltage.

C3 gives increased gain at a.c. to minimise ripple. R42 helps to define the gain of VT1. R17 and C4 provide the main loop time constants. C14 and C7 suppress possible parasitic oscillations. When S6 is depressed, the variable control system is disconnected from VT1 base. An adjustable reference current through R3 and RV3 and a fixed feedback current through R4 and MR6 are connected to VT1 base to give the fixed 5V output.

The current limit circuitry operates in a similar manner. The reference current is derived from the adjustable divider R1 and RV1, with R9, R10 and R11 as the series resistors. The switching in this case is arranged to allow only the lowest current limit selected to operate. The feedback current is through R12 and MR8. The voltage drop across MR8 cancels the base emitter voltage of VT2 so that the voltage across R12 is equal to that across R29. Similarly, the base emitter voltages of VT2 and VT6 cancel to stabilise the reference current. The output of the current sensing stage is OR-gated into the emitter of VT3 by MR10. C6 provides extra stabilisation of the loop in current limit mode.

The meter switching is entirely straightforward. RV4 on the voltage ranges or RV5 on the current ranges is adjusted to shunt the meter and obtain calibration. S1A and S1B switch the meter between voltage and current ranges. S2A on voltage and S2B on current short out part of the series chain to give the more sensitive meter ranges.

The circuit of the centre tap section, used only on 'D' option units, is shown in Fig. 3. On the 'D' option units, the auxiliary unregulated supply is regulated by R31 and MR14. This supply provides, via R34 and VT12, a constant current to the differential pair VT13 and VT14. These compare the centre tap voltage with a centre point voltage derived by divider R32 and R33. This differential pair drives the Darlington connected pair VT16 and VT17 which, in turn, drive the class 'B' push/pull output stage VT18, VT19, VT20 and VT21. R37 and VT15 form another current source, providing a dynamic load for VT16 and VT17. Output capacitors C8 and C9 are added to give good centre tap ripple and transient response. C10 and R39 determine the loop frequency response.

4.0 SETTING-UP PROCEDURE

Remove the cover from the unit by removing the two screws holding the carrying handle and the four small screws (two on each side) from the sides of the cover. Access to all preset potentiometers is gained through holes in the printed circuit board; their functions are marked on both sides of the board. Prior to switching on, zero the meter if necessary.

Switch on the supply, set the variable voltage control fully clockwise and depress the 7·5V (15V on 423) push-button. Adjust RV2 (SET V) to give an output of 7·6V Release the 7·5V (15V on 423) push-button and depress the 15V (30V on 423) button. With the variable voltage control still fully clockwise, check that the output voltage is 15·4 ±0·4V (30·8 ±0·8V on 423). Release the 15V (30V on 423) push-button and depress the 30V (60V on 423) push-button. With the variable voltage control still fully clockwise, check that this output voltage is 30·8 ±0·8V (61·5 ±1·5V on 423).

By means of the variable voltage control, set the output voltage to 30·0V (60·0V on 423) Adjust RV4 (SET METER V) so that the meter reads 30·0V (60·0V on 432) with both meter push-buttons released. By means of the variable voltage control, reduce the output voltage to 10·0V (20·0V on 423) Depress the lower meter push-button and check that the meter reads 10·0 ±0·2V (20·0 ±0·4V on 423). Release the lower meter button.

Set the variable voltage control fully clockwise and short circuit the unit through a d.c. ammeter. Adjust RV1 (SET A) to give a short circuit current of 0·55A (1·1A on 413). Release the 30V (60V on 423) push-button and depress the 15V (30V on 423) push-button. Check that the short circuit current is 1·1 ±0·1A (2·2 ±0·2A on 413). Release the 15V (30V on 423) push-button and depress the 7·5V (15V on 423) push-button. Check that the short circuit current is 2·2 ±0·2A (4·4 ±0·4A on 413).

Remove the short circuit, release the 7·5V (15V on 423) push-button and depress the 5·00V push-button. Adjust RV3 (SET 5V) to give an output of 5·00 ±0·01V

Depress the upper meter push-button. Apply a load of 2·0A (4·0A on 413) and adjust RV5 (METER A) so that the meter reads 2·0A (4·0A on 413). Reduce the load current to 1·0A (2·0A on 413), depress the lower meter push-button and check that the meter reads 1·0 ±0·02A (2·0 ±0·04A on 413).

The unit is now set up. Replace the cover.

5.0 SPECIFICATION

Line Supply:	110, 120, 220, 240V ±10% 50-60Hz selected by external voltage selector.

Outputs: (selected by push-button)	
403:	5V ±1% at 0·5, 1 or 2A 0-7·5V at 0·5, 1 or 2A 0-15V at 0·5 or 1A 0-30V at 0·5A
413:	5V ±1% at 1, 2 or 4A 0-7·5V at 1, 2 or 4A 0-15V at 1 or 2A 0-30V at 1A
423:	5V ±1% at 0·5, 1 or 2A 0-15V at 0·5, 1 or 2A 0-30V at 0·5 or 1A 0-60V at 0·5A
Line Regulation:	< 0·02% of maximum output for 10% line change
Load Regulation:	< 0·05% of maximum output for 100% load change NOTE: Maximum output refers to the maximum voltage on the range selected.
Ripple and Noise:	< 1mV peak-to-peak
Output Impedance:	typically 15m Ω at 1kHz
Temperature Coefficient:	< 0·02%/°C (typically at 25°C)
Transient Response:	Recovers to 50mV within 20μs for full load step change
Current Limit:	Nominally 110% of selected full load current
Meter Range: (selected by push-button)	
403:	0-10 and 0-30V; 0-1 and 0-3A
413:	0-10 and 0-30V; 0-2 and 0-6A
423:	0-20 and 0-60V; 0-1 and 0-3A
Centre Tap Tracking ('D' suffix only):	49 to 51% of total output ±100mV (down to 4V total output)
Centre Tap Line & Load Regulation, Ripple, Output Impedance & Temperature Coefficient:	As specified for full supply
Centre Tap Transient Response:	Recovers to 50mV within 30μs for full load step change
Operating Temperature Range:	0-45°C
Dimensions Over All Projections:	255mm deep a 180mm high x 153mm wide (10 x 7 x 6 inches)
Weight:	
403:	4kg (8lb. 13oz)
413 and 423:	4·4kg (9lb. 11oz)
For 'D' options, add:	0·1kg (3·5oz)

PARTS LIST

Main Assembly Power Supply - see Fig. 2

Circuit Ref.	Description	Value	Rating	Tol.	Type
Capacitors					
C8 (403/403D/423D)					
	Electrolytic	100μ	35/40V	−10, +50%	Mullard 016
C8 (413)	Electrolytic	220μ	35/40V	−10, +50%	Mullard 017
C8 (413D)	Electrolytic	220μ	25V	−10, +50%	Mullard 017
C8 (423)	Electrolytic	100μ	100V	−10, +50%	I. T. T. EN12.12
C9 (403/413/423)	Not Fitted				
C9 (403D/423D)	Electrolytic	100μ	35/40V	−10, +50%	Mullard 016
C9 (413D)	Electrolytic	220μ	25V	−10, +50%	Mullard 017
C13 (403/413/423)	Not Fitted				
C13 (403D)	Electrolytic	100μ	35/40V	−10, +50%	Mullard 016
C13 (413D)	Electrolytic	220μ	35/40V	−10, +50%	Mullard 017
C13 (423D)	Electrolytic	100μ	100V	−10, +50%	I. T. T. EN12.12
Control					
RV6 (403/413)	Wire Wound/Cermet	50k	1W	10%	Colvern CLR4001
RV6 (423)	Wire Wound/Cermet	100k	1W	10%	Colvern CLR4001
RV6 (403T/413T)	Wire Wound	50k		5%	Bourns 3509
RV6 (423T)	Wire Wound	100k		5%	Bourns 3509
Transistors					
VT10 (403)					2N3055
VT10, 20, 21 (403D)					2N3055
VT10, 11 (413)					2N3055
VT10, 11, 20, 21 (413D)					2N3055
VT10, 11 (423) and VT10, 11, 20, 21 (423D)					2N3055 Selected to $120V_{CER}$ at 27R
Miscellaneous					
T1 (403)	Transformer				W 1556 (Weir)
T1 (413)	Transformer				W 1557 (Weir)
T1 (423)	Transformer				W 1558 (Weir)
PL1	Pilot Lamp (red)		110V		Arcoelectric CL 267
BR1 (413 only)	Rectifier Bridge				Motorola MDA 990-2

Main Power Supply Printed Circuit Board - see Fig. 2

Resistors					
R1	Metal Oxide	2k0	1/2W	2%	Electrosil TR5
R2, 15, 22	Metal Oxide	2k2	1/2W	2%	Electrosil TR5
R3, 4, 10	Metal Film	20k	1/2W	1%	Electrosil C5
R5, 6, 11	Metal Film	8k2	1/2W	1%	Electrosil C5
R7	Metal Film	16k	1/2W	1%	Electrosil C5
R8, 12	Metal Oxide	2k7	1/2W	2%	Electrosil TR5
R9	Metal Film	10k	1/2W	1%	Electrosil C5
R13	Metal Oxide	10k	1/2W	2%	Electrosil TR5
R14	Metal Oxide	5k6	1/2W	2%	Electrosil TR5
R16, 18	Metal Oxide	1k5	1/2W	2%	Electrosil TR5
R17, 19	Metal Oxide	120R	1/2W	2%	Electrosil TR5
R20	Metal Oxide	680R	1/2W	2%	Electrosil TR5
R21	Metal Oxide	330R	1/2W	2%	Electrosil TR5
R23	Metal Oxide	27R	1/2W	2%	Electrosil TR5
R24	Metal Film	330R	1/2W	1%	Electrosil C5
R25	Metal Film	36R	1/2W	1%	Electrosil C5
R26	Metal Film	750R	1/2W	1%	Electrosil C5

Continued .....

PARTS LIST Continued

Circuit Ref.	Description	Value	Rating	Tol.	Type
R27 (403/413)	Metal Film	15k	1/2W	1%	Electrosil C5
R27 (423)	Metal Film	30k	1/2W	1%	Electrosil C5
R28 (403/413)	Metal Film	7k5	1/2W	1%	Electrosil C5
R28 (423)	Metal Film	15k	1/2W	1%	Electrosil C5
R29 (403/413)	Wire Wound	0R5	3W	5%	CGS PM3.5, C3A
R29 (423)	Wire Wound	1R0	3W	5%	CGS PM3.5, C3A
R30 (403)	Not Fitted				
R30 (413)	Wire Wound	0R5	3W	5%	CGS PM3.5, C3A
R30 (423)	Wire Wound	1R0	3W	5%	CGS PM3.5, C3A
R42	Metal Oxide	47R	1/2W	2%	Electrosil TR5
Capacitors					
C1	Electrolytic	470µ	35/40V	-10, +50%	Mullard 017
C2 (403)	Electrolytic	2200µ	63V	-10, +50%	Mullard 071
C2 (413)	Electrolytic	4700µ	63V	-10, +50%	Mullard 072
C2 (423)	Electrolytic	2200µ	100V	-10, +50%	Sprague WB35D
C3 (403/413)	Electrolytic	2µ2	63V	-10, +50%	Mullard 015
C3 (423)	Electrolytic	2µ2	100V	-10, +50%	I.T.T. EN12.12
C4, 6	Ceramic	2200p	500V	-20, +50%	Erie 831
C5, 7	Ceramic	1000p	500V	-20, +50%	Erie 831
C14	Ceramic	220p	500V	-20, +50%	Erie 831
Rectifiers					
MR1					1N4002
MR2, 3, 4, 5 (403/423)					1N4140
MR2, 3, 4, 5 (413)	Not Fitted				
MR6, 7, 8, 9, 10					1N4148
MR11	Zener				BZY 88C5V6
MR12	Zener				BZY88C8V2
MR13					1N4140
Transistors					
VT1, 2, 6					BC107
VT3 (403/413)					BCY70
VT3 (423)					2N3963
VT4 (403/413)					BC107
VT4 (423)					Motorola MPSA06
VT5 (403/413)					BFX29
VT5 (423)					BD528
VT7, 8					BCY70
VT9 (403/413)					BD577
VT9 (423)					BD581
Preset Controls					
RV1, 2	Carbon	500R		20%	Morganite 62H
RV3	Carbon	5k0		20%	Morganite 62H
RV4, 5	Carbon	100R		20%	Morganite 62H
Switch Assembly					
S1 to S7					AB 400-F02020-08-0-00

Auxiliary Printed Circuit Board ('D' options only) - see Fig. 3

Resistors					
R31	Metal Oxide	1k0	1/2W	2%	Electrosil TR5
R32, 33	Metal Film	6k8	1/2W	1%	Electrosil C5
R34	Metal Oxide	56k	1/2W	2%	Electrosil TR5

Continued .....

PARTS LIST Continued

Circuit Ref.	Description	Value	Rating	Tol.	Type
R35	Metal Oxide	27k	1/2W	2%	Electrosil TR5
R36	Metal Oxide	3k3	1/2W	2%	Electrosil TR5
R37 (403/423)	Metal Oxide	1k5	1/2W	2%	Electrosil TR5
R37 (413)	Metal Oxide	820R	1/2W	2%	Electrosil TR5
R38	Metal Oxide	4k7	1/2W	2%	Electrosil TR5
R39	Metal Oxide	120R	1/2W	2%	Electrosil TR5
R40,41	Metal Oxide	27R	1/2W	2%	Electrosil TR5
Capacitors					
C10 (403/423)	Ceramic	1000p	500V	20%	Erie 831
C10 (413)	Ceramic	390p	500V	20%	Erie 831
C11	Ceramic	2200p	500V	20%	Erie 831
C12	Plastic Film	0μ1	100V	20%	Mullard 344
Diodes					
MR14	Zener				BZY88C5V6
MR15, 16					1N4148
Transistors					
VT12, 13, 14, 15					BCY70
VT16, 17					BC107
VT18					BD577
VT19					BD578

TABLE OF COMPONENT EQUIVALENTS

Nominal Type	Equivalents
Mullard 015	Wima Printilyt, I.T.T. EN12.12
Mullard 016	Wima Printilyt, I.T.T. EN12.12
Mullard 017	Wima Printilyt, I.T.T. EN12.12
I.T.T. EN12.12 (100μ, 100V)	Siemens B41010
I.T.T. EN12.12 (2μ2, 100V)	Siemens B41313
Mullard 071	Sprague WB35D, CCL EH2245
Mullard 072	Sprague WB35D, Erie 31200
Sprague WB35D	Erie 31200
Erie 831	Lemco CD7K, Mullard C629
Mullard 344	I.T.T. PMC 1R, Wima MKS
Electrosil TR5	Welwyn MR5, Mullard MR30
Electrosil C5	Mullard MR30
CGS PM3.5, C3A	Welwyn W21, Painton LG716
Colvern CLR4001	May Precision M2, AB ABW2 Type 550
Bourns 3509	Beckman 7246, Spectrol 534
Morganite 62H	Iskra PN10B, Egen 522
1N4002	1N4003, 1N4004, 1N2070, BYX36-150
1N4140	Westinghouse S1M3, Solidev 3A100, Diodes Ltd. 3A1
1N4148	1N914
BC107	BC107B
BCY70	BC177V1
2N3963	Motorola MPSA56
Motorola MPSA06	Microelectronics ME8002
BD528	2N4031, 2N4033
BD577	BD579, BD581, 2N5298, Texas TIP29A
BD581	Texas TIP29C
BD578	BD580, BD582, Texas TIP30A
2N3055 (selected)	Motorola TE00461

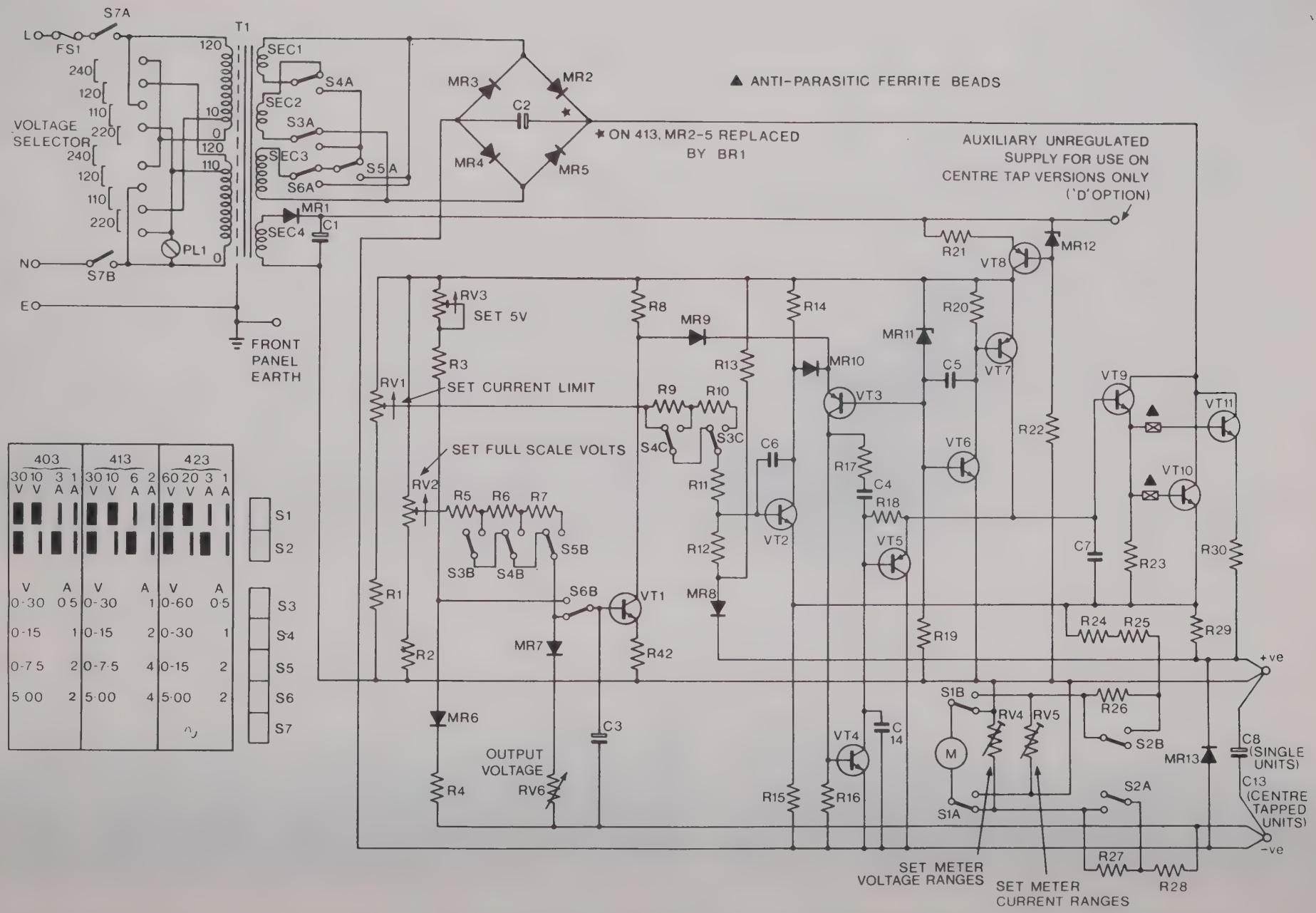

Fig. 2 Circuit Diagram of Main Assembly and Printed Circuit Board

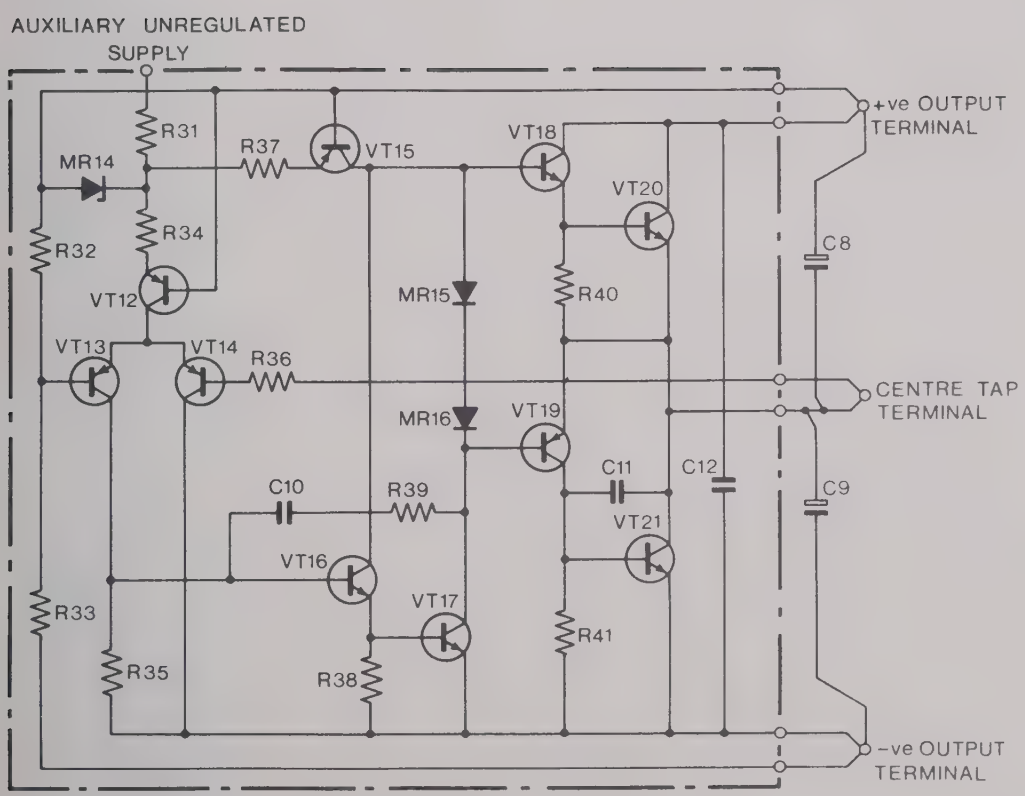

Fig. 3 Circuit Diagram of Auxiliary Printed Circuit Board ('D' options only)

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